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ABSTRACT

This paper considers research on visual-spatial learning differences between males and females and how such differences can be overcome in science and mathematics curricula. It is suggested that one reason females are underrepresented in the areas of mathematics and science is that they tend to score lower on spatial visualization aptitude measures, which are an important predictive measure for success in the fields of engineering, science, drafting, and designing. Possible explanations for these lower scores are explored, and it is suggested that research be undertaken to address the issue of how to improve the curriculum to encourage the development of visual-spatial experiences for women and girls. (5 references) (EW)

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Title:

SYMPOSIUM: **Technological Equity: Issues in Ethics & Theory**

Paper #3 **Visual-Spatial Learning: Issues in Equity**

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Visual-Spatial Learning: Issues in Equity

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Equity, that which is judged to be just or fair, is presumed to be a good thing. Equality, having the quality of of being equal, also is presumed to have a universal goodness inherent in its definition. However, when examined from a variety of perspectives, the terms equity and equality define related but different constructs whose pursuit can present some ethical and educational considerations. If we are concerned about women having skills equal to those of men, are we then not valuing those skills that are different from men? And if, for instance, there is some evidence that there is a lack of equal ability, then individuals who manifest less of whatever is being measured are quickly labeled as having a deficit (as opposed to those who have more being labeled as having a surplus). Equity, on the other hand, fosters fairness in opportunity. In our system of education, anyone has the right to develop aptitudes and abilities to their fullest potential. It is only just.

This paper discusses one such aptitude, visual-spatial learning, and some of the equity issues which are linked with it. It then outlines a program of research which might resolve some of the issues and exacerbate others. It sketches some of the ethical implications of the positions in the issues, and suggests dimensions which should be considered in research in order to ensure that the complex array of equity issues can be addressed.

Equity Issues

Fewer women than men enter professions which are built on mathematics and the physical sciences. There are many hypotheses for this phenomenon. A report by Lantz, Carlberg, and Eaton (1982) cites three major areas of differences between women choosing science and engineering and other women: interest, ability, and educational experiences. Women choosing careers in science and engineering are more interested in things than people and had more interest in mathematics and science. These women also tend to score higher on measures of ability, including verbal and mathematical aptitude, spatial visualization, science achievement, and grade point average. Educational experiences, as pointed out by the authors, are probably a result of the combination of the first two factors. Women scientists and engineers have more formal education in the sciences through increased choice of math and science courses, and they

also have more informal experiences with math and science because of participation in science clubs and hobbies.

Spatial visualization and orientation have shown to have strong predictive validity for estimating success of individuals in the fields of engineering, science, drafting, and designing (McGee, 1979). It is no surprise, therefore, that fewer women are in these fields since they also tend to score lower than men on visual spatial aptitude measures.

How does this happen? Sex related differences don't become reliable until puberty, and then the difference become obvious. McGee (1979) discusses four possible sources of variance in spatial test scores: environmental, genetic, hormonal, and neurological influences. Some posit that women are socially encouraged to be more nurturing and dependent upon human interaction. And whatever the reason, many girls and women perceive mathematics and science to be the domains of males. A third explanation might be that schools and teachers subtly or blatantly advise girls and young women away from scientific, mathematical or technical studies. Genetic influences are yet to be proven, although there is some evidence that spatial abilities are probably as, or more, heritable as verbal ability. Hormonal influences such as an estrogen-androgen balance are also considered as a factor, but like the question of genetic influences, this factor needs much more empirical evidence. On the other hand, neurological influences do appear to be strong. These influences center upon hemispheric specialization, and two issues continually arise in studies: (a) the right hemisphere specializes in spatial processing and (b) males have more hemisphere specialization than females.

Educators have no control over genetic and hormonal influences; and given the opportunity to structure learning experiences for hemispheric activity, perhaps educators have a little influence on neurological development. Our major arena of influence is the educational environment-social, curricular, instructional, and affective influences of everyday school life. Another plausible reason for lessened spatial skill development in females is that women have been educated to use a type of thinking which is not the most productive in learning these subjects.

Most education is based on language-based learning. In language-based learning, ideas are expressed as a linear sequence of related propositions (just as the ideas presented in this paper are formulated). Girls in the primary and intermediate grades excel in this form of learning and thus demonstrate superiority on most instructional tasks presented in the first half of elementary and secondary schooling. There is a great deal of conjecture as to whether this superior performance results from a natural developmental capability or whether it results from the social and cultural differences in experiences which young girls have. At the very least, superiority in language-based learning probably influences girls to rely on their success and to avoid or ignore experiences which require other types of cognition.

Visual-spatial learning is multidimensional and simultaneous. Such learning cannot be expressed adequately in language. It is involved in problem solving of all types, but is especially important in scientific problem solving in which a complex array of variables interact with each other. Visual-spatial thinking may involve multidimensional visual arrays (when these are restricted to three dimensions one is dealing with pictures) or may involve multidimensional arrays or networks of data. People who learn and think using visual-spatial processes sometimes do not communicate these ideas in traditional ways making assessment problematic.

Gagnon (1985) and others (Frostig, 1972; Salomon, 1979) have found that it is possible in a relatively short time to train women in visual-spatial thinking to a level of parity with men. In fact, Gagnon found that men who experienced the same treatment did not make significant gains. This study, conducted on college students (as are so many of our studies), suggests that remediation of the cognitive skill of visual-spatial learning is relatively simple. It does not address the issue that by the time a woman had entered college, there have been all sorts of learning opportunities lost because upper elementary and high school females do not manifest a high level of performance in visual-spatial thinking.

Program of Research

Boys and girls have been measured to have parity in visual-spatial skills until they reach early adolescence although variations in performance alternatively favoring girls and boys make the picture rather complex. It is at the time of puberty, however, that visual-spatial performance of boys begins to be measured consistently higher than that of girls. Since there is no evidence that some earlier experience of the boys might contribute to the results measured much later, it seems reasonable to study whether some intervention in the fourth, fifth or sixth grades would maintain parity for the females and whether such parity was a positive influence on their learning mathematical and scientific concepts or their attitudes regarding these subjects. In addition, longitudinal studies would be required to ascertain whether pre-pubertal intervention will be sufficient or whether continuing intervention will be required throughout middle and high school.

Should the visual-spatial experiences be prepared as integral to the mathematics and science curricula or should they be developed as specially focused exercises just for the females. Research needs to be conducted to find out whether integrated curricular experiences can be developed which are perceived by teachers to be "covering" the expected curriculum at the same time that they are encouraging development of visual-spatial thinking. Can these experiences be motivating to females? Will the experiences have more powerful effects on the males (the rich get richer problem) or will such experiences slow the intellectual development for them?

Will teachers, who being mostly female do not understand visual-spatial thinking well themselves, be able to guide the learning of visual-spatial thinking by being sensitive to the subtile cues of translation of visual tasks into propositional tasks (an inefficient process often used by girls when confronted with a spatial task). How can teachers best be encouraged to develop visual-spatial thinking themselves. Can they experience powerful effects of their own visual-spatial thinking in their management of complex classroom environments? What sort of support system will be necessary to encourage commitment to visual-spatial matters after the novelty wears off?

How can social and cultural factors in the differential rearing of boys and girls interact with the cognitive and manipulative experiences in visual-spatial thinking to enhance the abilities of females in scientific and technical study. Can curricula in mathematics and science be developed which construct meaning in ways more in harmony with feminist culture? Can examples and problems be developed which will both be interesting and motivating to females and be stimulating of visual-spatial thinking?

Ethical Analysis

There would seem to be little doubt that a person should be able to function as well as her or his biology allows. Yet social, cultural and economic factors have served to limit people not only in accessing the means for the development of capability but also have focused individuals or groups on particular goals and aspirations. Contemporary society has increasingly voiced the goal of removing barriers to individual development. In addition, the increasing dependence of all on the products of technology has increased the importance of scientists, engineers, technicians, technical writers, and technical managers for the maintenance of convenience, comfort and (we hope) quality in life.

Women comprise slightly more than half of the population. Yet women represent a small minority in scientific, technological and management fields. Some might claim that women have other very significant roles in society. Yet there is widespread evidence that these "other" roles for women are neither valued by being powerful nor by being well-paid. It is surely too simplistic to claim that women are so underrepresented in science and technology because they perform less well in visual-spatial thinking, but if visual-spatial thinking is a factor, isn't it appropriate that educators and educational researchers should work to provide experiences for female learners to eliminate it?

Dugger (1986) feels that equity is a matter of balancing a variety of possibilities for the individual regardless of the gender of the individual or the traditional gender association of that trait. Under the discipline of this position, while girls were being encouraged to learn and use visual-spatial skills, boys would be learning nurturance or some other helpful, positive "female" trait. Addressing the notion of balance in curriculum and instructional design would be a complex task which would require the

designer/developer to be concerned about a much wider range of variables than have been considered traditionally.

A third approach to curriculum and instructional design might be to attempt to develop gender neutral lessons for all people. Such an effort is probably doomed for many reasons including "traditional" expectations for schooling, the artificiality of pretending that gender does not apply, and the boring nature of most anything that is homogenized.

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